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DRY SEASON AGGREGATIONS OF INSECTS IN AUSTRALIAN MONSOON FORESTS

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ABSTRACT

Observations are recorded on aggregation behaviour by insects in monsoon forest patches in tropical Australia during the dry winter months. Species of the Hemiptera, Lepidoptera and Diptera were involved, some of which normally inhabit open forest but which migrate into the monsoon forest patches to form aggregations. The behaviour is interpreted as having a group defence function whereby natural defences of distastefulness, repugnatorial glands or buzzing behaviour are reinforced by massed individuals.

INTRODUCTION

The northern third of Australia experiences a tropical monsoon climate with a pronounced wet season occurring during the summer months of December to April under the influence of the northwest monsoon air flow. Typically, the rest of the year is very dry. This highly seasonal rainfall pattern is not normally adequate to support true tropical rainforest (closed forest) except in areas where the monsoonal rains are augmented by other rain systems which reduce the impact of the monsoonal dry season. This only occurs along the eastern seaboard of Queensland where the combined effect of a moist southeast airflow off the Pacific Ocean and the orographic influence of subcoastal mountains yields the necessary rains for fully developed evergreen rainforest. However, in the remainder of the tropical zone several types of closed canopy forest occur which are floristically and structurally similar to true rainforest but are usually referred to as 'monsoon forest' because of their lower plant diversity and tendency to deciduousness in the dry season. They include several of the structural categories of Australian rainforests defined by Webb (1978). They can be regarded as a type of rainforest which has developed under extreme seasonality of rainfall. Monsoon forests in Australia are very limited in area and occur as small patches and strips in favourable locations in Cape York Peninsula, the 'Top End' of the Northern Territory and the Kimberleys. Their boundaries are clearly defined and they generally stand in marked contrast to the open eucalypt/melaleuca forests and woodlands which surround them.

During the hot, dry season conditions in the open forests are extremely harsh and the pockets of shady, moist monsoon forest become important refuges for many animal species. This is conspicuous in the grazing mammals, for instance, and in the Northern Territory the monsoon forest patches are shelters for wallabies and feral buffalo, pigs and cattle which feed in adjacent grasslands. This behaviour is poorly documented among the insects but recent observations by the author during a collaborative project (Kikkawa and Monteith, 1980) indicate that some butterfly species normally restricted to open forest shelter in the monsoon forests during the dry season (e.g. *Acraea andromacha* (Fabricius) *Danaus chrysippus* (Linnaeus), *Junonia orithya* (Linnaeus)). A remarkable related phenomenon is the formation of massive aggregations of certain insect species which persist in a semiquiescent state for several months in these monsoon forests during the dry season. This behaviour has received only cursory mention in the Australian literature. The present paper presents new field observations on this behaviour, summarizes the sporadic literature and discusses the possible significance of these aggregations.

RECORDS OF INSECT AGGREGATIONS FROM AUSTRALIAN MONSOON FORESTS

In the following account insect species are discussed systematically under order and family. Where no other source is cited the observations were made by the writer. Most of these were made during a 4 week visit to the Northern Territory in July, 1979, during which insect surveys were conducted in eleven monsoon forest patches. In nine of these, insect aggregations were encountered. The localities and the insect species concerned are tabulated in Table 1.

HEMIPTERA : SCUTELLERIDAE

Lampromicra senator (Fabricius) 1803

On May 21, 1972, clusters of up to 50 individuals of this metallic green species were found hanging from shrub foliage in gallery monsoon forest along Beame's Brook, 30 km SW of Burketown, Gulf of Carpentaria. The insects were tightly packed, semiquiescent and showed little inclination to disperse when disturbed. At the same site crow butterflies (*Euploea core* Cramer) were also aggregating. McDonald (1963) records *Lampromicra senator* in southern Queensland as breeding on the shrub *Breynia oblongifolia* in open forest and hibernating as adults in winter in various concealed situations. At Beame's Brook the clusters were quite exposed and occurred on several species of plants, not all of which could have been *Breynia*. It is assumed that the bugs had migrated into the monsoon gallery forest to pass the dry winter. In southern Queensland another scutellerid, *Cantao parentum* (White), undergoes mass over-wintering, adult clustering, often on non-host plants to which it migrates (McDonald, 1963; pers. obs.)

HEMIPTERA : ALYDIDAE

Leptocorisa acuta (Thunberg) 1783

This slender, grass-feeding bug is widespread in northern Australia and may become a pest of rice. Its biology in Papua New Guinea has been studied by Sands (1978). In the Northern Territory it was found aggregating in five of the monsoon forest patches in July (Table 1), particularly at Kemp Airstrip where enormous numbers occurred (Plate 1C). At none of the sites were grasses, the normal foodplant, present. The insects rested quietly in clusters beneath leaves or in rows along twigs and petioles of low shrubs and ferns, never more than a metre above the ground. When disturbed the clusters burst into buzzing, brief flight, discharging their repellent scent glands, before settling again in the original site. Sands (1978) describes a pattern of behaviour in this species in Papua New Guinea where onset of dry weather triggers migration from open grassland to shaded sites where gregarious aestivation for up to two months takes place. He noted heavy egg mortality during dry weather and interpreted the migration-aestivation behaviour of adults as a reproductive strategy to counter this. Undoubtedly the clustering seen in monsoon forests of Northern Australia is the same phenomenon, but with a much longer dry season the period of aestivation there probably reaches 5–6 months.

Noliphus erythrocephalus Stal

This species was noted clustering with *Leptocorisa acuta* at the Kemp Airstrip forest in July (Table 1), where it was greatly outnumbered by *L. acuta*. Similar mixed clusters of *Leptocorisa* and *Noliphus* have also been noted in gallery monsoon forest along the Stewart River in Cape York Peninsula in late June, 1976. At the latter site some pure clusters of *Noliphus* were observed (Plate 1B). Like *Leptocorisa acuta, Noliphus erythrocephalus* appears to be principally an open forest species and thus this clustering activity away from the normal habitat is probably a similar migration-aestivation behaviour to that described for *Leptocorisa*.

HEMIPTERA : COREIDAE

Gralliclava australiensis Dolling, 1978

This small bug is distributed across the tropical north of Australia (Dolling, 1978) where it feeds on pods of leguminous herbs such as *Crotalaria* spp., principally in open forest. In July, 1979, it was found in considerable numbers in four lowland, monsoon forest patches in the Northern Territory (Table 1). It occurred there in small clusters, usually of no more than six individuals, in concealed situations such as rolled dead leaves, abandoned spider retreats among shrub foliage and among leaf litter on the ground. The insects in these small clusters were semiquiescent when disturbed and reluctant to disperse but eventually discharged their repugnatorial glands. At the time of observations no suitable foodplants for the bugs occurred inside the monsoon forest patches, and in the surrounding open forest where foodplants did occur there were no apparent *Gralliclava*. For this reason it is assumed that populations of bugs had migrated into the monsoon forest patches.

TABLE 1: PRESENCE OF AGGREGATIONS OF INSECT SPECIES OBSERVED IN 9 MONSOON FOREST TRACTS IN THE NORTHERN TERRITORY DURING JULY, 1979.

SPECIES \ SITES	Mt. Gilruth Gorge 13·02Sx133·05E	Radon Creek 12·45Sx132·53E	Cahills Crossing 12·25Sx132·58E	South Alligator R. 12·40Sx132·30E	West Alligator R.(1) 12·12Sx132·13E	West Alligator R.(2) 12·11Sx132·16E	Kemp Airstrip 12·35Sx131·20E	North Point 12·25Sx132·22E	Ininowinyin Gorge 12·23Sx133·03E	Favoured Aggregation Sites
Coptosoma lyncea (Hemiptera: Plataspidae)			X							tree foliage
Noliphus erythrocephalus (Hemiptera:Alydidae)							X			low herbage and grasses
Leptocorisa acuta (Hemiptera:Alydidae)			X	X	X	X	X			low herbage and grasses
Gralliclava australiensis (Hemiptera:Coreidae)				X	X	X		X		in curled leaves and litter
Euploea core (Lepidoptera:Nymphalidae)		X	X	X	X		X	X		trunks and roots of 'banyan' fig trees; sheltered rock faces; tree foliage
Euploea sylvester (Lepidoptera:Nymphalidae)		X	X	X	X		X	X		trunks and roots of 'banyan' fig trees; sheltered rock faces; tree foliage
Danaus affinis (Lepidoptera:Nymphalidae)					X					tree foliage
Euphumosia papua (Diptera:Calliphoridae)	X	X	X						X	sheltered rock faces near water
Pericyna sp. (Diptera:Dolichopodidae)	X									base of tree trunks
sp. indet. (Diptera:Milichiidae)	X									foliage hanging over stream bed
Totals	3	3	5	4	5	2	4	3	1	

HEMIPTERA : PLATASPIDAE

Coptosoma lyncea Stal

This stink bug was found in one very large aggregation and in several smaller clusters on broad-leaved trees at one monsoon forest locality in the Northern Territory in July, 1979 (Table 1). Several species of trees were involved so it is assumed that at least some of the aggregations were not on foodplants of the bug. The largest aggregation occurred on a tree about 5 m in height, of which every single leaf was covered with bugs (Plate 1D). The bugs assumed a regular spacing on the underside of leaves and in rows along the petioles, giving the initial impression of being a natural pattern of galls or blemishes on the plant. The insects rested immobile when undistrubed and none were seen to feed on the plant. When disturbed, large numbers of bugs took flight instantly, accompanied by loud buzzing and by discharge of stink glands. After several minutes all returned to their original roosting tree and became quiescent again.

DIPTERA : DOLICHOPODIDAE

Sympycnus sp. cf. *apicalis* de Meijere

This small, long legged fly was found in several aggregations on the base of tree trunks in monsoon forest at the bottom of a gorge near Mount Gilruth in July, 1979 (Table 1). The flies formed dense-packed carpets of individuals, usually ovate in shape and up to about half a square metre in area. When disturbed they were reluctant to take flight and soon settled into a quiescent swarm again. It is not known whether monsoon forest is the normal habitat of this species.

DIPTERA : MILICHIIDAE

gen. & sp. indet.

One cluster of this tiny black species was observed on low hanging foliage above the dry creek bed in a deep shady part of the gorge at Mt. Gilruth (Table 1). The flies densely covered several terminal leaves of a branch and were normally immobile (Plate 1A). When disturbed, the flies exhibited mass flight activity accompanied by high pitched buzzing before eventually settling down again on the original leaves. This cluster was above a path used by our collecting party and was disturbed many times during the 3 days work at that locality, but it never moved from its site. The flight buzzing closely resembled that of a disturbed wasps' nest and is thought to be defensive. It is not known if monsoon forest is the normal habitat of this species.

DIPTERA : CALLIPHORIDAE

Euphumosia papua Guérin - Meneville

This large, strikingly-coloured blowfly was recorded from Arnhem Land by a previous survey (CSIRO, 1975) and their report comments on its commonness in sandstone areas. Its breeding habits are unknown but Ferrar (1978) descibed the larvae. In July, 1979, it was noted aggregating at 4 sites in Arnhem Land (Table 1), always on shaded rockfaces and usually near water. Groups of up to several thousand individuals occurred, resting quietly and were sluggish when disturbed and reluctant to fly.

LEPIDOPTERA : NYMPHALIDAE

Euploea core corinna (W.S. Macleay) 1826

The Common Crow is a ubiquitous butterfly of northern and eastern Australia where it is principally an open forest species. Like most other danaines its larvae feed on toxic plants and the adults are considered to be distasteful to birds. There are a number of passing remarks in the literature concerning sightings of aggregations of this species but these do not appear to have been summarized. In the following they are treated, together with various unpublished observations, geographically by States:

QUEENSLAND: Alexander (1933) records a roosting site near Westwood 45 km W of Rockhampton. The aggregation occurred in *Casuarina* trees on a creek bank and some butterflies occupied the site at all times of the day. Alexander notes that the roosting site seemed active at all times of the year during his 3 years' residence at Westwood. McCubbin (1971) writes that this species 'congregates during winter at various places around the coast. Large numbers collect in sheltered gullies on some Barrier Reef islands including Lindeman Island, Hayman Island, Brampton Island and Magnetic Island.' McCubbin also records observations of J.C. LeSouef that 'hundreds gather during winter on bamboo clumps in both Rockhampton and Darwin gardens.' Monteith (1972) records clusters of the species on *Pandanus* foliage in gallery forest along Beames Brook near Burketown on May 21, 1972. A map accompanying Anonymous (1974) shows an aggregation site for *Euploea core* seen in August, 1973 at the bottom of a sandstone gorge in the Isla Gorge National Park, near Theodore. Unpublished observations of aggregations in Queensland are those by M. DeBaar (pers. comm.) of clusters in clefts between boulders at Laura Gorge in June, 1978, and by R. Molnar and G. Czechura (pers. comm.) of massed butterflies on rock overhangs and trees at the bottom of Porcupine Gorge, near Hughenden, in June 1980. Three occurrences of these aggregations of *Euploea core* have been witnessed by the writer in Queensland. The first was on May 23, 1968, when a dense roost of between two and four thousand individuals was encountered on several shady trees clumped together on the bank of Major's Creek, at the western base of Mt. Elliot, near Townsville. The second was in June, 1971, when a very large aggregation was seen extending for about 50 metres on dense, shady trees overhanging a dry anabranch channel of the Coen River, near Coen township. The third was in June 1971, at a sandstone outcrop 30 km west of Fairview, near Laura, where small quiescent clusters of butterflies occurred on cool, shaded rockfaces around the base of the outcrop.

NORTHERN TERRITORY: McCubbin's (1971) mention of LeSouef's observation of *Euploea core* aggregating on bamboo clumps in Darwin gardens has already been noted. LeSouef (1971) records

having seen many hundreds resting in a patch of 'Jungle' (= monsoon forest) along the Daly River in June, 1970. S. and K. Breeden (1975), writing on the sandstone massifs of Arnhem Land in May, illustrate a cluster of this species on a twig and state that 'hundreds of these butterflies crowd together in dark corners of the escarpment's rainforests'. During the writer's visit to Northern Territory in July, 1979, aggregations of this butterfly were found in six of the nine monsoon forest patches studied (Table 1). One of these was in a gorge in the Mount Brockman sandstone (Radon Creek) where the butterflies rested on shaded, overhanging rockwalls at the head of the gorge. The remaining five aggregation patches were on the plains where the monsoon forest occurred either as gallery strips along watercourses (South Alligator, Cahill's Crossing) or as small isolated patches surrounded by open sclerophyll forest (West Alligator 1, Kemp Airstrip, North Point). At these plains sites aggregation foci were provided by the interwoven roots and trunks of the giant 'banyan' fig trees, *Ficus virens*, where the dense shade given by their evergreen crowns yielded the coolest, darkest part of the forest (Plate 1E & F). All these aggregations behaved similarly. The butterflies rested quietly, with heads upwards, but were quite alert. When approached there appeared to be a critical distance after which a small group of butterflies suddenly launched into swirling flight. This activity had a chain reaction effect, triggering others until the whole swarm joined the flight. Then slowly they settled back into their original positions until within a couple of minutes all were quiet again.

WESTERN AUSTRALIA: Bailey and Richards (1975) describe 'large and spectacular aggregations' of *Euploea core* in mangroves at King Cascade and on rock faces in vine thicket at Enid Falls during August, 1974. Both these localities are in the Prince Regent River region of the Kimberleys which is more or less the western limit of the species' range in Australia.

Euploea sylvester (Fabricius), 1793

Two subspecies of the species occur in Australia, *E. sylvester sylvester* (F.) along the eastern Queensland coast and *E. sylvester pelor* Doubleday and Hewitson, 1847 in the north of the Northern Territory and the Kimberleys of Western Australia. Aggregation behaviour has been recorded in both subspecies. Kershaw (1915) describes *E. s. sylvester* in the monsoon forest at Iron Range, in Cape York Peninsula, in November 1913 where 'hundreds . . . . . were flying about, while dozens could be seen resting on a single dead tree, several being taken with one sweep of the net.' In the Northern Territory the writer recorded *E. s. pelor* as a minor component of all of the clusters of *Euploea core* noted (Table 1). Specimens of *E. sylvester* were hard to distinguish from *E. core* when resting or flying but from captures it is estimated that they never exceeded about 5% of the aggregations. They indulged in the same flight activity described for *E. core* above.

Euploea tulliolus tulliolus (Fabricius) 1793

The only record of an aggregation is that of Waterhouse (1932) who says that 'on Lindeman Island, near Mackay, I once saw this butterfly in hundreds settled on the trees in a shaded gully, and was able to catch many specimens with one sweep of the net.'

Euploea eichhorni Staudinger, 1884

M. DeBaar (pers. comm.) records this species aggregating with *Euploea core* in shaded clefts between boulders at Laura Gorge in June, 1978.

Danaus affinis affinis (Fabricius) 1775

This species is often very common in coastal situations across northern Australia. At one of the sites surveyed in the Northern Territory in July, 1979, it was found resting in numbers with aggregating *Euploea core* (Table 1). However, the *D. affinis* were much less quiescent than the *Euploea* spp. and random flight activity took place.

Danaus hamatus hamatus (W.S. Macleay) 1826

This butterfly occurs across northern Australia and down the east coast. In some years it builds up to large numbers during summer and migrations may occur along the coast during the autumn. During these migrations large concentrations of butterflies may build up on capes, headlands and some off-shore islands. Such concentrations were observed and commented on by some of the earliest explorers. For example, on Cook's first voyage along the east coast in 1770, on May 29 at Thirsty Sound, they found 'butterflies . . . . the air was for the space of 3 or 4 acres crowded with them to a wonderful degree . . . . yet every branch and twig was almost covered with those that sat still' (Banks, 1962). Later, Phillip Parker King (1826) noted similar swarms at Cleveland Bay in

June, 1819, 'as well as every other place we had landed upon within the tropic'. In more recent time McNeil (1937) noted an enormous camp on Hayman Island in May, 1933, which dispersed for feeding during the day and roosted together at night. McCubbin (1971) refers to aggregations in sheltered gullies on Lindeman and Magnetic Islands and speculates that the species migrates to congretation sites in the winter months. In April, 1981, great numbers accumulated around lighthouses at Sandy Cape, on Fraser Island, and at Bustard Head during a migration (P. Sutton, pers. comm.). More than 10 discrete aggregations of this species were noted on South Percy Island on November 14, 1981 (G. Rees, pers. comm.), each having a proportion of specimens in active flight during daylight hours. Notwithstanding McCubbin's speculations, it seems that the aggregations of *Danaus hamata* are of a different nature to those described for *Euploea* spp. in that they never become completely quiescent and there are no records of long occupation of a single aggregation site. It seems best to regard them as temporary, topographically-induced concentrations of migrating populations. There are other Australian records of temporary migration-associated aggregations of Lepidoptera which also seem quite unrelated to the long term seasonal aggregations in tropical monsoon forests being described here, viz. *Anaphaeis java teutonia* (Fabricius) 1775 and *Catopsilia pyranthe crokera* (W.S. Macleay) 1826 in Sydney (Waterhouse & Lyell) 1914; *Pieris rapae* (Linn.) 1758 in Adelaide (McFarland, 1971); *Danaus chrysippus petilia* (Stoll) 1790 near Perth (Alexander, 1933); and *Alcides zodiaca* Butler in North Queensland (Coleman & Monteith, 1981 and references therein).

DISCUSSION

The dry-season aggregation behaviour described in this paper appears to be a specialized phenomenon of the mosoon zone of Australia, all localities mentioned lying within the northern band where the influence of the monsoonal dry season is most marked. In this respect it is notable that there are no records of aggregations from the Cairns region (Mossman to Ingham), a climatic enclave within the monsoon zone where the winter dry season is dispelled by orographic rain systems. This is despite the fact that all species of Hemiptera and Lepidoptera discussed occur there. The Cairns region is heavily populated and much frequented by naturalists so it is unlikely that aggregating insects there would go unnoticed. Long-term aggregations of insects south of the monsoon zone in Australia are the exception but include summer congregations of Bogong Moths *(Agrotis infusa* (Boisd.)) on summits of the Australian Alps (Common, 1954) and winter roosts of the introduced Monarch butterfly, *Danaus plexippus* (Linneaus) in southern Australia (Smithers, 1965). The latter butterfly's behaviour in Australia is an incipient version of its well-documented migration-aestivation behaviour in its native North America (Urquhart, 1960).

While short-term communal roosting of butterflies, either during migrations as mentioned earlier, or as a regular nocturnal habit of certain species, e.g. South American heliconiines (Poulton, 1931; Benson & Emmel, 1973), is a frequent occurrence in the tropics, there are few recorded parallels overseas of the long-term aggregations of Australian *Euploea* spp. An exception is the study of the nymphalid, *Smyrna karwinskii* (Geyer) by Muyshondt & Muyshondt (1974) in El Salvador. This species migrates from lowlands to highlands during the dry season and forms small compact clusters of up to 100 individuals which remain quiescent for up to six months. The great numbers of individuals in the clusters of *Euploea core* in Australia seem unique among tropical butterflies.

The association of this aggregation behaviour with the dry season in tropical Australia is also clear, all records summarized being referable to the period from April to November. The only exception to this is Alexander's (1933) note on the aggregation of *Euploea core* at Westwood which he reports as being present at most times of the year during his 3 year's residence there.

The propensity of the insects for monsoon forest as their aggregation site is strong. The attractive feature of monsoon forest appears to be the cool, shady microclimate it affords. In the absence of monsoon forest other localized sites which offer a similar deep shade are selected. These include gorges, rock faces and groups of shady trees, particulary adjacent to water.

Although actual observations of migratory movements are lacking for the species concerned, it seems clear that for at least some species there is movement of populations from their normal open forest habitat into the monsoon forest patches at the end of the wet season for the purpose of forming aggreations. Those species for which we know sufficient of their normal habitat to be able to assume that such migration takes place include the bugs, *Lampromicra senator, Leptocorisa acuta, Noliphus erythrocephalus, Gralliclava*

australiensis and the butterfly *Euploea core corinna*. The same assumption of seasonal, inter-habitat migration can be made for certain non-aggregating species of insects also. In the Northern Territory the eminently 'open forest' butterflies, *Acraea andromacha*, *Danaus chrysippus* and *Junonia orithya* may be found inside monsoon forest at the height of the dry season (pers. obs.). A.L. Dyce and H.A. Standfast (pers. comm.) report that in the same region there is a contraction of populations of open forest frequenting mosquitoes (Culicidae) and biting midges (Ceratopogonidae) into the monsoon forest patches during the dry season. Similar dry season habitat changes are seen in certain bird species (Kikkawa et al., in press). Such habitat shifts are significant in the Australian context where there is generally a very basic difference in the biota inhabiting closed forests and open habitats. Within the monsoon zone the importance of the small areas of closed canopy monsoon forest as seasonal refugia for the fauna of the whole region is highlighted.

The function of the aggregating behaviour itself appears to be one of group reinforcement of the natural defences of the individual insects. All the Hemiptera and Lepidoptera species concerned have chemical defences against predation in the form of either toxic body fluids derived from toxic food plants (the butterflies) or volatile, repugnatorial secretions emitted from metapleural scent glands (the Hemiptera). Clearly these defensive powers are magnified in the aggregations. The massed flight behaviour of the aggregations when disturbed also has an apparently defensive function. The swirling, chain reaction of massed flight seen in roosting areas of *Euploea* species is quite spectacular and could be assumed to be confusing and alarming to a potential predator. In the Hemiptera where sudden massed flights were elicited by disturbance of aggregations (*Leptocorisa acuta* and *Coptosoma lyncea)* flight was accompanied not only by discharge of the repugnatorial glands but also by sudden loud buzzing similar to that of a disturbed paper-wasp nest. This combination of factors yielded considerable fright reaction, even in humans coming suddenly on an aggregation. For the aggregating Diptera observed, the group defence function of the behaviour is not so obvious. The exception is the sudden high-pitched buzzing of disturbed clusters of the milichiid species which also gave a wasp-nest fright response in humans.

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PLATE 1

A. Aggregating flies of the family Milichiidae on foliage near Mount Gilruth, Northern Territory, July 1979.

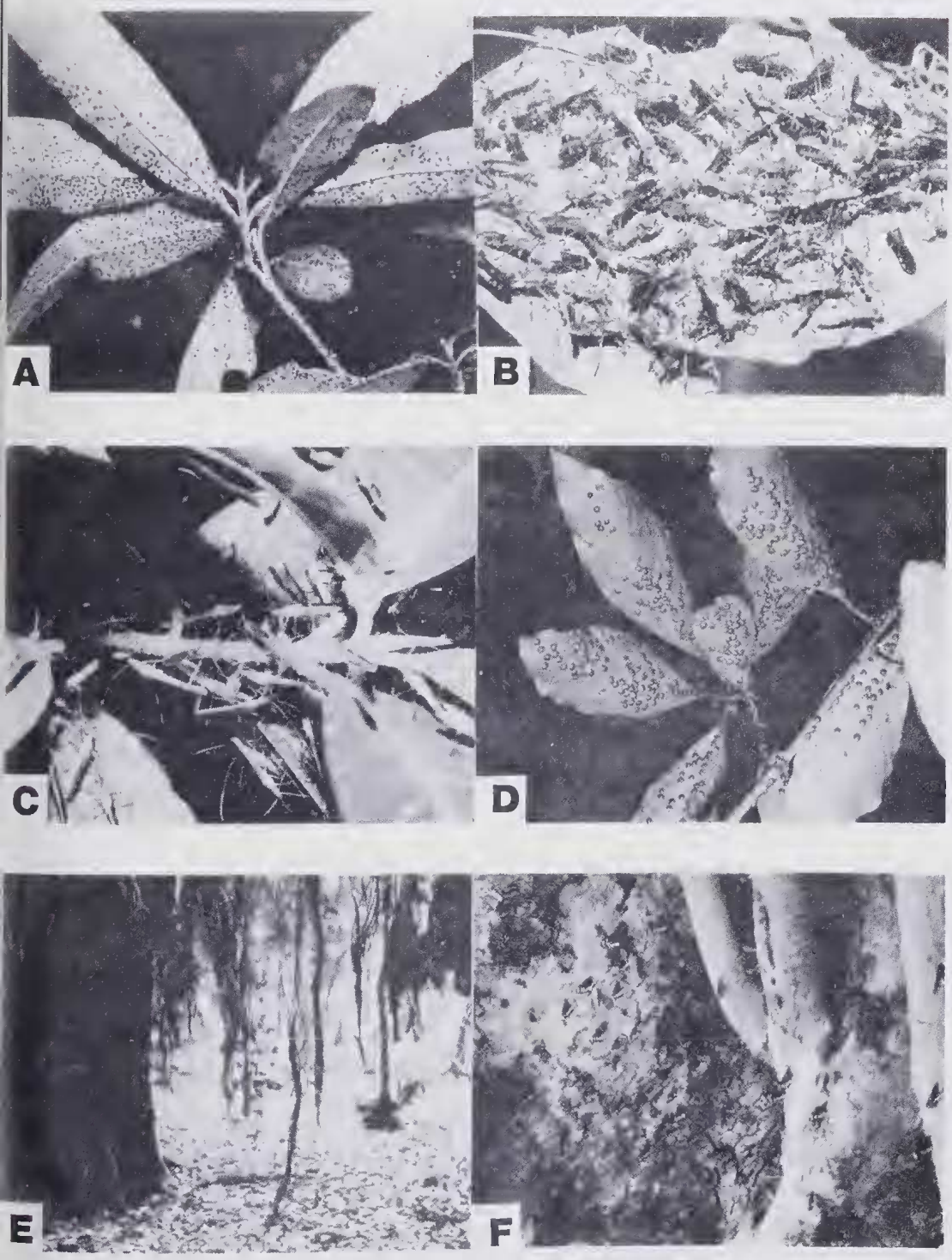
B. A pure cluster of the alydid bug, *Noliphus erythrocephalus*, on foliage at the Stewart River, Cape York Peninsula, June 1976.

C. *Leptocorisa acuta*, clustering of foliage at Kemp Airstrip, Northern Territory, July 1979.

D. Quiescent aggregation of the plataspid bug, *Coptosoma lyncea* on foliage at Cahill's Crossing, Northern Territory in July 1979.

E. *Euploea core* and *E. sylvester* resting on aerial roots of *Ficus virens* at North Point, Northern Territory, July 1979.

F. *Euploea core* and *E. sylvester* resting on trunk of *Ficus virens* at North Point, Northern Territory, July 1979.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